SAFETY IMPACTS OF "ROAD DIETS" IN IOWA

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Introduction

A "road diet", converting a roadway from four lanes to three lanes (one through lane in each direction and a two-way, continuous left-turn lane), is frequently suggested as a solution to left-turn related crashes on undivided four-lane roadways where widening may not be an option. Fifteen of these conversions have been completed in Iowa and this report presents an analysis of the safety impacts of these "road diets."

With the objective of assessing whether "road diets" result in crash reductions on Iowa roads, the Iowa Department of Transportation (Iowa DOT) Office of Traffic and Safety (TAS) funded two independent effectiveness evaluations. The first utilized a classical before-and-after (B/A) study with "yoked-pair" control sites and was conducted by researchers at the Center for Transportation Research and Education (CTRE). The second utilized a full Bayes (FB) approach and was conducted by the Iowa State University Department of Statistics in cooperation with TAS.

Both studies utilized the same 15 treatment and 15 control sites. The B/A study examined annual data (crashes, crash types, and volumes) with comparisons to annual crash trends both citywide and to similar, unconverted roadways (i.e., "yoked pair" control sites). The FB study utilized monthly crash data and estimated volumes obtained from the TAS for the 30 sites over 23 years (1982-2004). The sites had traffic volumes ranging from 2,000 to 17,400 annual daily traffic (ADT) during that time span and were mostly located in smaller urbanized areas (ranging in population from 1,169 to 198,682 according to the 2000 Census).

The results of the B/A study indicated reductions of 28% in crash frequency and 21% in crash rate. The results from the FB study largely agree with these numbers and indicate a 25.2% reduction in crash frequency per mile (density) and an 18.8% reduction in crash rate. These results differ from a previous, much publicized study (1,2,3) which reported a 6% reduction in crash frequency per mile and an insignificant indication for crash rate effects. These results from the Iowa studies also fit practitioner experience with this type of left-turn treatment. Additionally, the B/A study explored crash type, severity, and age-group effects . The results of these explorations are all positive, with a reduction in crash types associated with left-turn and stopped traffic, a 34% reduction in the number of injury crashes, and reductions in involvement of at-risk age groups.

Literature Review

Huang et al evaluated twelve "road diets" and twenty-five comparison sites in Washington and California (1,2,3). They found that the road diets had an average crash frequency that was only 6% lower than the corresponding comparison sites, that crash severities were not affected, that crash types did not change significantly, and that crash rates did not change from before to after.

In 2001, CTRE published a final report by Knapp and Giese (4) which presented guidelines for the conversion of 4-lane roadways to a 3-lane configuration. They discussed case studies in Montana, Minnesota, California, and Iowa. In all cases there were reductions in crashes after the conversions, either in absolute values, rates of crashes, or both. They also reported that levels-of-service were not "dramatically decreased" by the conversion.

Research Process

The Iowa DOT Office of Traffic and Safety (TAS) maintains a rich, statewide crash database. This database provides a consistent, readily available source of crash data for several Iowa countermeasures effectiveness studies, including these "road diet" studies.

For the classical analyses, the data covered 5 years before (in all but one case) and up to 5 years after the conversions. The classical before-after study compared the changes in the crashes at the conversion sites to the changes in the sites' cities, as well as to crash patterns at similar comparison sites. The analyses conducted in this study addressed crash frequency, rate, severity, type, driver age, and major cause.

For the Bayesian analyses the process used monthly crash data covering 23 years, as well as estimated traffic volumes provided by TAS. Each treatment site had different known intervention dates; therefore, the number of before and after crash records varied from site to site. Individual control sites (the same as used in the classical study) were matched to each treatment site to provide a control sample similar to the treatment sample. Given the random and rare nature of crash events, a hierarchical Poisson model where the log mean was expressed as a function of time period, seasonal effects, and a random effect corresponding to each site included was fitted to the crash frequencies.

A full Bayesian (FB) approach (5,6) was adopted for estimation of model parameters. In the Bayesian approach, model parameters are treated as random variables and the goal is to estimate the distribution of likely values of the parameters given prior and data information. The approach differs from classical methods in that distributions of likely values (rather than point estimates) and standard errors of parameters are obtained, and in that all results are conditional on the sample at hand. One other fundamental difference between the classical and the Bayesian approaches to estimation is that prior information about model parameters can be combined with information contained in the sample to draw inferences. This is not possible within the classical framework. The Empirical Bayes (EB) approach (7), currently promoted in the traffic safety field, is a special case in the Bayesian paradigm where prior distributions are partially based on the sample. The distribution of likely values of model parameters on which all inferences are based is known as the joint posterior distribution. (For a more complete explanation, see http://www.dot.state.ia.us/crashanalysis/pdfs/iowa4to3laneconversion_fullbayes_june2005.pdf).

Results

The two study methods produced similar results. The classical study found a 28% reduction in total crash frequency and 21% reduction in total crash rate, when compared to the overall city crashes. The Bayesian study observed that, despite the fact that both treatment and control sites experienced reductions, the treatment sites' experience was greater, resulting in a 25% reduction in crash density and a 19% reduction in crash rate. These results differ from a previous Huang, et al. study (1,2,3), which indicated very little reduction.

The differences between the FB analysis and the analysis performed by Huang are several and may explain the diverging results. First, even the descriptive analysis of the "raw" data suggests that the effect of conversion in Iowa roads was much more dramatic than in the roads considered in the Huang study. Second, Huang fitted an ordinary linear regression model to the expected crash frequencies, meaning that a single slope for expected frequency on time was assumed for the entire study period whereas the FB analysis model incorporated components which explicitly allowed for different slopes during the "before" and the "after" periods. Third, Huang's study, though it began with 12 treatment sites and 25 control sites, was reduced to 8 treatment sites and 14 control sites for the crash rate analysis due to unavailability of data. Additionally, Huang utilized only 3 years of data for both the before and after period. (See http://www.dot.state.ia.us/crashanalysis/pdfs/trb_roaddiet_papersubmission_08012005.pdf for a more complete discussion.)

Table 1 presents the changes in crash frequencies determined from the B/A analysis for the conversion sites, their cities, and the yoked or comparison sites.

CITY	SEGMENT	CITY	DIFFERENCE	SEGMENT	YOKED	DIFFERENCE
Storm Lake	-47	-21	-26	-47	-54	7
Mason City	-56	-5	-51	-56	30	-86

Osceola	-53	-13	-40	-53	-11	-42
Manchester	-27	-17	-10	-27	-39	12
Iowa Falls	-62	-17	-45	-62	-38	-24
Rock Rapids	-67	-23	-44	-67	-3	-64
Glenwood	-50	-33	-17	-50	-19	-31
Des Moines	-42	-20	-22	-42	-11	-31
Council Bluffs	-75	-34	-41	-75	19	-94
Blue Grass	-75	-68	-7	-75	-5	-70
Sioux Center	-65	-53	-12	-65	-33	-32
Indianola	-17	-24	7	-17	-18	1
Lawton	-67	-57	-10	-67	-22	-45
Sioux City	-40	-28	-12	-40	-5	-35
Average	-53	-30	-24	-53	-15	-38

Table 1 –Percent Changes in Crashes for Study Segments, Cities, and Yoked Pairs

SOME DISCUSSION?

The DOT was equally interested in changes in crash types. Table 2 shows the changes in crash frequency from the B/A analysis in types of crashes.

CITY	Head-On	Rear-End	Angle/Left-turn	Broadside	Sideswipe-same	Sideswipe - opposing	Unknown
Blue Grass	25.0	-47.9	-100.0	-50.0	-72.2		-91.7
Council Bluffs		-89.6	66.7	66.7	-100.0		-100.0
Des Moines	-58.3	9.8	-84.2	6.4	87.5	150.0	-61.1
Glenwood	-30.8	-28.8	0.0	-34.7	37.5	300.0	-86.7
Indianola	-37.5	19.9	-50.9	1.6	42.9		-77.9
Iowa Falls	-9.1	-72.2	-64.3	-100.0	-100.0	150.0	-100.0
Lawton		-100.0	-100.0	-16.7	-58.3		-100.0
Manchester	150.0	8.7	-75.0	-50.0	87.5	-100.0	-100.0
Mason City	25.0	-85.3		-16.7	-100.0		-100.0
Osceola	-31.8	-35.8	13.6	-74.1	-91.7	25.0	-100.0
Rock Rapids	0.0	-71.4	-100.0	0.0	-90.0		-100.0
Sioux Center	-89.6	0.7	-81.4	-37.5	-54.2	25.0	-95.5
Sioux City	-58.3	66.7		-58.3	66.7		-100.0
Storm Lake	1066.7	128.4	-68.3	-60.0	-69.7		-52.4
Overall	-41.7	-35.0	-73.5	-40.9	-49.3	100.0	-85.2

Table 2 – Percent Change in Type of Crash for Study Segments

SOME DISCUSSION?

The Iowa DOT was particularly interested in the potential decrease in injury crash frequency due to “road diets”. Figure 1 graphically summarizes the results of the B/A analysis of injury crashes. When compared to the city crashes, major injury crashes at the converted sites were reduced by 11%, minor injury crashes by 30%, and possible injury crashes by 31%. Overall, injury crashes were reduced by 34%. Due to their rarity, fatal crashes were included as major injury crashes.

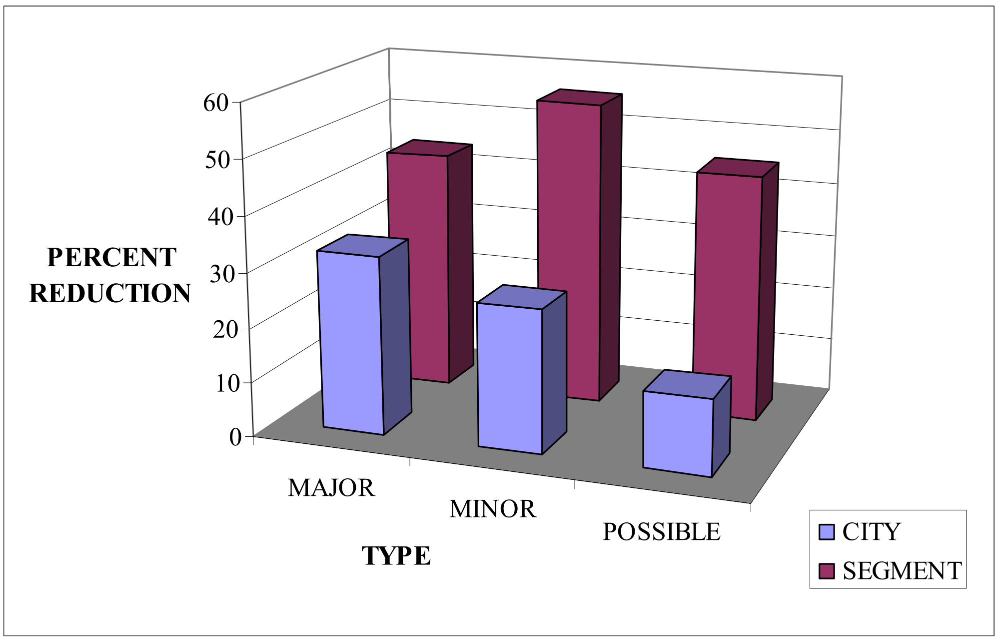

Figure 1 – Before and after comparison of injury crashes

Iowa has a relatively high proportion of elderly drivers (population?); Iowa DOT requested an investigation into whether older drivers have a higher rate of involvement in crashes after the conversions. Figure 2 shows the breakdown by age of drivers in crashes in the study segments for the before and after cases. The result of these conversions is that the proportional involvement of older drivers was reduced; drivers under 25 similarly had a reduced proportion of involvement in crashes after conversion.

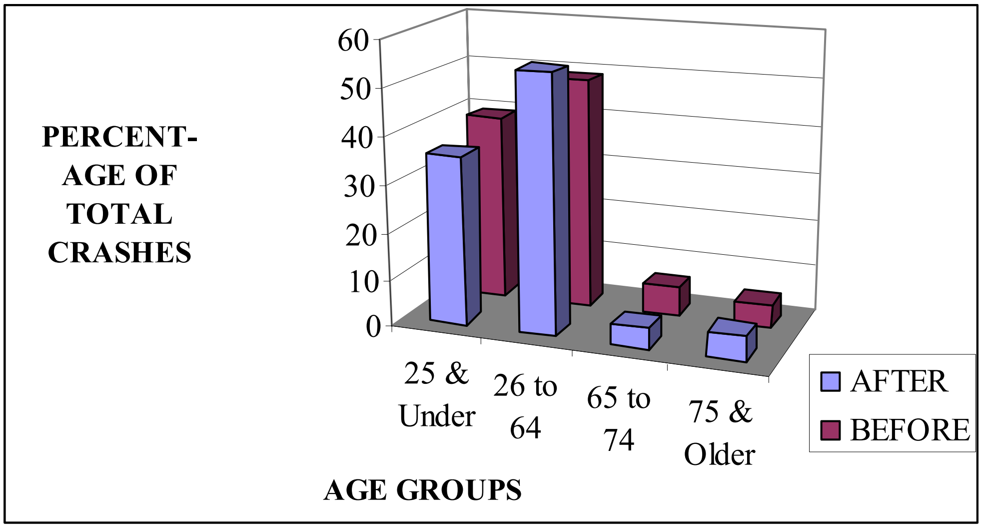

Figure 2 – Driver involvement by Age for all sites, in percent

Conclusions

There are a number of benefits that can be realized from the conversion of 4-lane undivided roadways to 3-lane cross sections in selected locations where physical or environmental constraints prohibit options that involve widening. The benefits found in this study include the following:

- A 25% reduction in crash frequency per mile and a 19% reduction in crash rate. This differs from the Huang, et al. study which reported a 6% reduction in crash frequency per mile.
- A similar reduction in the number and severity of injury crashes
- Reductions in the involvement of age groups that are traditionally at risk, those 25 and under as well as those 65 and older
- A significant reduction in the number of crashes types related to left-turns and stopped traffic.
- A 34% reduction in the number of injury crashes, as well as a reduction in the severity of the crashes that do occur.

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